Rule 21
Working Group Report:

Report to the CPUC and the CEC
In response to CPUC Decision 05-08-013

Developed by:
California Rule 21 Working Group

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Introduction

On August 25, 2005 the CPUC issued Decision 05-08-013 ("Decision") in rulemaking proceeding 04-03-017, requiring changes to Rule 21, which is the rule under which California Electric Utility Corporations ("ECs") review and approve interconnections of Distributed Generation ("DG") to their electric distribution systems. The Decision called for several actions by the ECs and the Rule 21 Working Group ("Working Group"). The CPUC has since closed proceeding 04-03-017 and opened proceeding R.06-03-004 in its place.

Since the Decision, the Working Group has held six meetings, with several smaller meetings held by the Process subgroup, the Technical subgroup, the three ECs, and others. The Working Group has developed guidelines for handling interconnection to "network" distribution systems. The Working Group also discussed the allocation of up-front fees and costs affecting customers who have multiple generators located at one site that receive different tariff schedule treatment. The Working Group reached agreement on Net Generating Output metering, additional pre-parallel inspections, a more streamlined dispute resolution process, and a process for posting the dispute resolution on the website http://www.rule21.ca.gov/. The Working Group also discussed kWh allocation treatment for determining NEM eligible credits where there is one or more NEM eligible generating facility and one or more non NEM generating facility located at the same customer's site. The ECs have already filed tariffs for Combined Technologies, and the advice process will resolve any remaining issues.

Report Format

This report provides the findings and directives of the Rule 21 Working Group as required by CPUC Decision 05-08-013 on rulemaking proceeding 04-03-017 (since replaced by proceeding R.06-03-004). The proceeding addressed issues that the Rule 21 Working Group believed required regulatory resolution. The Decision asked for several changes by the ECs, and also called upon the Working Group to resolve several issues.

The format of this report is to address the Working Group items in the Decision, one at a time. The directives in the Ordering Paragraphs of the Decision are addressed in Section 1; other directives to the Working Group are addressed in Section 2.

Section 1

This section addresses the directives to the Working Group in the Ordering Paragraph of the Decision. The relevant language from the Decision is shown in italics, followed by the Working Group's position.

Ordering Paragraph 3

The Rule 21 Working Group shall develop the procedure for providing the information and the types of information that should be included at the website required herein regarding resolution of interconnection disputes.

The Working Group prepared the procedure and types of documents related to the resolution of a dispute that should be posted on the website http://www.rule21.ca.gov Paragraph G.4 of the

revised Rule 21 provides direction on what should be on the website, who should provide it, and when.

Ordering Paragraph 4

The Rule 21 Working Group shall develop proposed rules for DG interconnections to distribution systems that have a network configuration. It shall also propose how to allocate costs and payments for DG facilities that include two NEM generators operating under different tariffs. The Working Group shall file its recommendations on these topics with this Commission and the CEC no later than March 31, 2006;

This order requires two separate actions:

i) Proposed rules for DG interconnection to network distribution systems; and
ii) Allocation of interconnection costs and energy export credits for multiple NEM generators.

i) The Rule 21 Working Group has developed a report describing the Network systems in California and the existing GFs connected to Networks. The report identifies existing requirements and processes throughout the country that address Network Interconnection, outlines cost examples, and defines potential issues. The report also presents a potential Initial Review Process Screen for Grid Networks that would allow Simplified Interconnection of small inverter-based GFs. This screen will be used on a trial basis to determine proper criteria.

Developing the preceding status review has given the Rule 21 Working Group members a better perspective on the situation in California, contact with a wide range of interested parties, and exposure to the debate in other venues. Through this review, a number of unresolved issues have been identified. While it is possible that many of these will be of little or no consequence, some will result in specific requirements for and limitations to Network Interconnection. The report's recommendations show that there is still significant work to do to arrive at consensus requirements. The Rule 21 Working Group should continue to participate in the various ongoing activities that are attempting to resolve these issues, including IEEE P1547.6, the MDGC and other state collaborative groups, and DUIT.

ii) For multiple generators operating under different NEM tariff provisions, the ECs have filed advice letters that propose allocation of credit for exported energy. [1] However, allocation of interconnection costs for customers with both NEM eligible generator(s) and non NEM generator(s) has not been fully addressed. As of the filing date of this report, the Working Group had not finalized recommendations. This effort will be continued in future meetings.

Section 2

This section addresses issues that the Decision asked the Working Group to resolve, but were not in the Ordering Paragraph:

1. ***(Dispute resolution)*** *We encourage the Working Group to refine this procedure and the types of information that should be included at the website, as the CEC suggests. We will direct the utilities to submit tariff changes consistent with the foregoing (dispute resolution) and following consultation with the Working Group.*
2. ***(Website postings for DG dispute information)*** *We also direct the Rule 21 Working Group to develop the procedure for providing the information and the types of information that should be included at the website.*
3. ***(Dispute Information Posting)*** *The Rule 21 Working Group should develop the procedure for providing the information and the types of information that should be included at the website regarding resolution of interconnection disputes.*

[1] PG&E AL 2793-E, SCE AL 1969-E and SDG&E AL 1777-E

The Working Group reached agreement on dispute resolution and on what information should be posted, and the process for posting the information on the Rule 21 website (http://www.rule21.ca.gov/). The information and posting process is addressed in Section G of the revised Rule 21 advice letter filings.[2]

4. ***(Net Generation Output Metering (NGOM))*** *The CEC recommends the Rule 21 Working Group develop tariffs to implement these recommendations. The utilities would then submit tariff changes by advice letters. We adopt the recommendations of the CEC with regard to NGOM and herein direct the utilities to submit tariff modifications following consultation with the Rule 21 Working Group.*

The issue of need, ownership and costs for Net Generation Output Metering was resolved. Paragraph F.3 of ECs' revised Rule 21 advice letter filings implements the resolution.

5. ***(Relative to Combined Technology Tariffs)*** *We herein direct the Working Group to develop technical and administrative solutions to these and other implementation issues. In the interim, the utilities shall modify their tariffs to incorporate the policy and associated implementation rules in advice letter filings.*
6. ***(Costs and payments for combined generation)*** *We will direct the Working Group to propose ways to treat such facilities and address the matter in a subsequent decision.*

Over the past several Working Group meetings there has been extensive discussion regarding "Combined Technologies," defined as a customer site where more than one generator is interconnected, and where the rate treatment for each generator is different. . For multiple generators operating under different NEM tariff provisions, the ECs have filed advice letters that propose allocation of credit for exported energy. However, allocation of interconnection costs for customers with both NEM eligible generator(s) and non NEM generator(s) has not been fully addressed. The Working Group will continue to address the cost allocation issue.

7. ***(Network Interconnections)****The CEC supports this process. We will direct the Working Group to pursue it and report its progress to the CEC and trhis Commission in a formal filing to be made no later than March 31, 2006.*

The report about interconnection to network systems, *Interconnection of Distributed Resources on Secondary Network Distribution Systems,* was developed and is attached to this document as an appendix and will also be posted on the Rule 21 website (http://www.rule21.ca.gov/technical_issues/network).

8. *(Net Generation Output Metering requirements and responsibilities) The EC's shall file modifications to Rule 21 of their respective tariffs no later than six months from the effective date of this order that modify Rule 21 for each utility as follows:*

   DG facilities that do not receive regulated subsidies do not need to install net generation output metering (NGOM) where less intrusive and/or more cost-effective options for providing output data are available, consistent with existing Rule 21;DG

[2] PG&E AL 2792-E, SCE AL 1971-E and SDG&E AL 1776-E

facilities may opt to have the utilities estimate load data for purposes of calculating a DG facility's cost responsibility surcharge if the distributed generation (DG) owner does not wish to purchase NGOM, but DG facilities on a departing load-cost responsibility surcharge (DL-CRS) tariff may opt to install NGOM if the project objects to the utility's estimates of CRS liability;

The Working Group did reach consensus on revised NGOM language for tariff Rule 21. The agreed upon Working Group language was incorporated in tariff Rule 21, paragraph F.3, and included in the advice letter filings[3].

9. ***(Developer Access to Utility Technical Data)*** *EC shall provide to the DG project developer all relevant regulatory and/or technical detail regarding interconnections requirements where the EC and the DG project developer dispute the EC's requirements.*
10. ***(Dispute Mediation)*** *For cases where a utility and a DG owner are unable to resolve an interconnection dispute informally, Rule 21 shall provide for a dispute resolution procedure that requires the parties to request a mediator from the Commission or to engage a third party mediator by mutual agreement*

The Working Group reached resolution on these issues. The process for the EC to provide the developer with relevant technical documents is included in paragraph G.2 and G.4 of tariff rule 21 advice letter filings[4].

11. ***(Additional Inspections for Interconnection Acceptability)*** *A cost-based charge for DG project interconnection inspections for those inspections that are extraordinary and/or follow the first inspection.*

The Working Group reached consensus on this issue. A cost-based charge for extraordinary inspections has been incorporated in tariff Rule 21, in table C-1, also incorporated in paragraph E.2.a, and such changes are included in the Rule 21 advice letter filings[5].

[3] Ibid
[4] Ibid
[5] Ibid

Acknowledgements

This report was facilitated by the cooperation and support from many individuals in the Working Group; the CEC and the CPUC provided valuable information and guidance in its preparation. A special note of appreciation to Scott Tomashefsky of the Northern California Power Authority who set up the Working Group when he was with the CEC; thanks to Scott, the Working Group has been able to find solutions even when the parties began far apart. Thanks to Dave Michel and Jose Palomo, the CEC Project Managers for their fine efforts; and to Werner Blumer of the CPUC, whose meticulous precision and command of language helped hone the rule. The earlier work of Eric Wong, also formerly of the California Energy Commission, and of Tom Dossey of SCE is also recognized. The FOCUS team (Edan Prabhu, Chuck Whitaker, Chuck Solt and Joe Simpson) expresses its thanks to the Working Group for the cooperation and resourcefulness shown in tackling these sometimes contentious issues.

APPENDIX

California Electric Rule 21
Working Group Report:

Interconnection of Distributed Resources on Secondary Network Distribution Systems

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I. Introduction

Under California Public Utilities Commission (CPUC) Decision no. 05-08-013 on CPUC OII 04-03-017, the California Energy Commission was asked to review issues related to the interconnection of Generating Facilities (GF) to Secondary Network Distribution Systems (Networks) to determine what changes might be facilitated in Rule 21, what guidance might be offered for Supplemental Review, and what additional data/information would be useful in establishing concrete requirements. In response the CPUC request, the Rule 21 Working Group developed a Network Interconnection Work Plan, shown in Annex A. This report describes the information obtained and the conclusions reached by the Rule 21 Working Group following that Work Plan. This report assumes a basic understanding of Networks. A general description of Networks, including definitions, drawings, basic designs, equipment, and a preliminary list of issues related to GF interconnection is provided in the DUIT report *Network Distribution Systems Background And Issues Related To The Interconnection Of Distributed Resources* as referenced in Annex B.

II. Background

Networks are historically used to provide high reliability electric service to critical load customers. These distribution systems are characterized by the use of specialized Network-style relaying that prevents reverse power flow from the Network back to the utility under certain fault conditions.

Most network systems are old; the last California Grid Secondary Network was installed in the 1970s. PG&E and SMUD have both added to their Networks since then, but only as Spots.

Rather than installing new Grid or Spot Secondary Networks, reliability in new or expanding urban areas is more commonly provided using a system of multiple utility sources (feeders) with manual or automatic transfer switches. This system does not employ any Network style relaying and doesn't present any special GF interconnection issues. These techniques have been employed in San Diego and Los Angeles, neither of which has any Secondary Networks.

Customers served by Networks tend to have the wherewithal and, in increasing numbers, an expressed desire to incorporate some form of customer-sited generation. However, Network's special design presents a new set of challenges to GF interconnection. When the Rule 21 Working Group originally considered Network interconnection in 2000, no consensus could be reached, so the Initial Review Process immediately shunted those applications to Supplemental Review. It was the intent of the Working Group to come back to this issue, and provide more definitive guidance. This report represents the beginnings of the effort to do just that.

III. Definitions

The following definitions were derived from those in the DUIT Network Report (Annex B), which provides further discussions and diagrams of how networks are constructed.

Consistent definitions are critical to understanding and communicating the design and operation of Secondary Network Distribution Systems. Alternate definitions for some of the following terms may be found in different regions. These definitions represent, by consensus, the most common usage.

Cable Limiter: An enclosed fuse for disconnecting a faulted cable in a Secondary Network Distribution System and for protecting the un-faulted portion of that cable against serious thermal damage.

Cycling: Undesirable cyclical tripping and closing of a Network Protector due to external (load) conditions. Left unchecked, Cycling may eventually lead to failure of the Network Protector. (Contrast with "Pumping").

Grid Network: A Secondary Network System with geographically separated Network Units, with the Network-side terminals of the Network Protectors interconnected by low-voltage cables that span the distance between sites. The low-voltage cable circuits of the Grid Network are typically highly meshed, supplied by numerous Network Units. Also referred to as Area Network or Street Network.

Network Master Relay: An electro-mechanical polyphase relay with two functions: 1) opening of the Network Protector when power flow is from the low voltage side to the high voltage side of the Network Transformer; and 2) closing of the Network Protector in conjunction with the electro-mechanical Network-phasing relay when transformer voltage is higher than Network voltage and leads the Network in phase angle.

Network Protector: An assembly comprising a circuit breaker and its complete control equipment for automatically disconnecting a transformer from a Secondary Network Distribution System in response to predetermined electrical conditions on the primary feeder or transformer. The device will also connect a transformer to a Secondary Network Distribution System either through manual control or automatic control responsive to predetermined electrical conditions on the feeder and the Secondary Network Distribution System. NOTE—The Network Protector is usually arranged to automatically connect its associated transformer to the Secondary Network Distribution System when conditions are such that the transformer, when connected, will supply power to the Secondary Network Distribution System and to automatically disconnect the transformer from the Network when power flows from the Secondary Network Distribution System to the transformer. [from IEEE C57.12.44-2000]

Network Protector Fuse: A backup protective device in series with the Network Protector.

Network System: A collection of Spot Networks, Grid Networks, or combinations of such Networks and the primary feeders that supply them.

Network Transformer: A transformer designed for use in a vault to feed a variable capacity system of interconnected secondaries. Note: A Network Transformer may be of the submersible or of the vault type. It usually, but not always, has provision for attaching a Network Protector. (From IEEE C57.12.80-1978). Dry type transformers are also used for Spot Network applications.

Network Unit: A Network Unit consists of primary disconnect and grounding switch, Network Transformer, and Network Protector.

Primary Network Feeder: A feeder, radial in nature, that supplies energy to a Secondary Network Distribution transformers or the combination of a Secondary Network Distribution transformers and other radial loads. (Dedicated Primary Network Feeders supply only Network Transformers for the Grid or Spot Networks; non-dedicated, or combination, feeders supply both Network and radial loads). (not to be confused with a primary network)

Pumping: Rapid, uncontrolled, unintentional, and intolerable repetitive tripping and closing of a Network Protector, normally due to a failure in the Network Protector control circuitry. If not promptly detected and corrected, Pumping will quickly lead to failure of the Network Protector. (Contrast with "Cycling").

Secondary Network Distribution System (or "Network"): An AC power distribution system in which customers are served from three-phase four-wire low-voltage circuits supplied by two or more Network Transformers (and at least two primary Network Feeders) whose low-voltage terminals are connected to the low-voltage circuits through Network Units. The Secondary Network Distribution System has two or more high-voltage primary feeders, with each primary feeder typically supplying between 1 and 30 Network Transformers, depending upon Network size and design. The system includes protective devices designed to isolate faulted primary feeders, Network Transformers, or low-voltage cable sections while maintaining service to the customers served from the low-voltage circuits. Unless otherwise stated, in this document the term "Network" means the Secondary Network Distribution System.

Spot Network: A Secondary Network Distribution System consisting of two or more Network Units at a single site where each unit is connected to a separate primary feeder. The low-voltage Network side terminals of these Network Units are connected together with bus and/or cable, with the resultant interconnection structure commonly referred to as the paralleling bus or collector bus. In Spot Networks, the paralleling (collector) bus typically does not have any low-voltage ties to any adjacent or nearby Networks. Such Spot Networks are sometimes called isolated Spot Networks, to differentiate them from Spot Networks with Reach (see below).

Spot Network with Reach: A Spot Network with secondary voltage cable connections to one or more neighboring Spot Networks or to a nearby Grid Network. These reach connections are usually of a capacity limited to the rating of one of the Network Units supplying either Spot Network.

Underground Connector: Underground connectors located in manholes and transformer vaults that provide for multiple connections at a single junction point.

IV. California Status

This section describes the Secondary Network Distribution Systems in California and the known Generating Facilities located within those networks.

A. Spot and Grid Secondary Network Distribution Systems in California

Within California, approximately 22,500 customers (almost 0.2%of the State's 13.5M customers), representing 1.1%of the State's peak load, are served by secondary networks, either

grid or spot. While these numbers seem low, these customers tend to represent very high-value economic interests, which implies a need for high reliability service the desire for options like distributed generation, and the financial wherewithal to create a credible market segment. The following sections provide some of the details of secondary networks by utility.

1. Pacific Gas and Electric (PG&E)

PG&E has Network Systems located in each of the two major Northern California metropolitan areas in their service territory: San Francisco and Oakland.

a. San Francisco Network Distribution System

The Network Distribution System in San Francisco consist of eight 12 kV groups and two 34.5 kV groups. Each 12 kV group serves a specific geographic portion of the downtown area while the two 34.5 kV groups have no fixed boundaries.

PG&E uses two types of secondary network systems. The Grid Network consists of an interconnected grid of low voltage cables that are energized from multiple primary feeder circuits utilizing 12 kV to 120/208 Volt step-down transformers. The Spot Network consists of 2 or more 277/480 Volt step-down transformers where the secondaries are connected together. The primaries of each transformer in a Spot Network are supplied from separate feeders. A Spot Network serves only one, large customer.

Each of the eight 12 kV network groups consists of a low voltage, secondary grid and Spot Networks. The 10 secondary grids range in size from 11 square blocks to 46 square blocks. The two 34.5 kV groups consist of only Spot Networks.

By using multiple or redundant facilities, this type of electrical system provides extremely reliable service continuity and is utilized to serve the high density, commercial downtown metropolitan area of San Francisco. Types of customers include high-rise office buildings, data processing centers, major telecommunications centers for the SF Bay Area, large retail stores, plus a number of residential buildings. The majority of the load in the network is made up of only 400 to 500 high density commercial and retail customers.

In support of the network distribution system, the 4 substations are also design with multiple transformer banks and transmission feeds or supplied by multiple substation-to-substation intertie cables. All network feeders in a particular group are supplied from a common bus.

1. GENERAL STATISTICS:

Area Served: 1.2 sq. miles (total S.F. area is 45 sq mi)
Historic Peak Load: 420 MVA

Network Groups: 10
Network Feeders: 57
Transformers: ~ 1100 (49% grid & 51% spot units)
Number of Vaults: ~ 650

Total Customers: 17,420
Domestic: 12,670
Commercial: 4,750

b. Oakland Network System Description

The Oakland Network service area covers approximately 1 square mile in the downtown Oakland area. The Network Distribution System in Oakland consists of two 12 kV groups of circuits. There are 2 substations that supply the network groups. Each of the two 12 kV network groups consists of a low voltage, secondary grid and Spot Networks.

PG&E utilizes two types of secondary network systems. The Grid Network system consists of an interconnected grid of low voltage cables that are energized from multiple primary feeder circuits utilizing 12 kV to 120/208 Volt step-down transformers. The Spot Network consists of 2 or more 277/480 Volt step-down transformers where the secondary sides are connected together as a common bus. The primary side of each transformer in a Spot Network is also supplied from separate feeders. A Spot Network usually serves one large customer or high rise building only.

By utilizing multiple or redundant facilities, this type of electrical system provides extremely reliable service continuity and is utilized to serve the high density, commercial downtown metropolitan area of Oakland. Types of customers include high rise office buildings, data processing centers, retail stores, large residential buildings and major telecommunication centers for the East Bay area. In support of the network distribution system, the two substations are also designed with multiple transformer banks and transmission feeds. All network feeders in a particular group are supplied from a common bus at the substation to achieve ultimate reliability.

1. GENERAL STATISTICS:

- Area Served: 1 sq. mile
- Historic Peak Load: 82 MVA
- Network Groups: 2
- Network Feeders: 12
- Transformers: 212
- Number of Vaults: 110
- Total Customers: 1400

2. Southern California Edison (SCE)

SCE has a single Network System in the downtown area of the City of Long Beach

a. Long Beach Network System Description

1. Boundaries

The Network service area encompasses the urban downtown area of the City of Long Beach. The service boundaries of this 80 square blocks system are from Seaside Way North to 7th, and from Daisy East to Alamitos. Notable landmarks within the Network service boundary include Lincoln Park and Long Beach Plaza.

2. Design

The Network area is served from multiple substation transformers. Service continuity at the customer level can be maintained for a number of outage situations, including individual service transformers failures, feeder failures or even substation transformer failures. Furthermore, an additional layer of redundancy can be found for a small majority of Network customers. This additional layer is the Secondary Grid system, which ties entire vaults together in parallel at the secondary service voltage level. This added layer allows the removal of one or more entire vaults from service without any service interruptions to those customers that are connected to the Secondary Grid system. There are about a dozen Secondary Grid systems, served from seven primary feeders.

3. Statistics

Peak Load (MVA):	44	Total Customer Meters:	1,100
Number of Primary Networks:	1	Number of Primary Feeders:	7
Number of Secondary Grids:	12	Number of Grid Vaults:	44
Number of Spot Vaults:	8	Number of Grid Transformers:	110
Number of Spot Transformers:	20		

4. Loading

The Network system is comprised predominately of high-density commercial and retail type customers.

3. San Diego Gas and Electric

San Diego Gas and Electric Company has no Grid or Spot Network systems.

4. Sacramento Municipal Utility District (SMUD)

SMUD's Network System is in downtown Sacramento

a. Sacramento Network System Description

1. Boundaries

The Network service area encompasses approximately 580 acres in the heart of the Sacramento metropolitan downtown area. The service boundaries of this 120 square blocks system are from the Sacramento River to the west, east through 21st Street, and from Q Street north to F Street. Notable landmarks within or adjacent to the Network service boundary include the California State Capital Building, Sacramento River and Old Sacramento.

2. Design

The Network area is served from multiple substation transformers. Service continuity at the customer level can be maintained for a number of outage situations, including individual service transformers failures, feeder failures or even substation transformer failures. Furthermore, an additional layer of redundancy can be found for a small majority of Network customers. This additional layer is the Secondary Grid system, which ties entire vaults together in parallel at the secondary service voltage level. This added layer allows the removal of one or more entire vaults from service without any service interruptions to those customers that are connected to the secondary grid system. There are a total of 10 distinct Secondary Grid systems, five from each substation.

3. Statistics

Peak Load (MW):	81	Total Customer Meters:	2,549
Number of Primary Networks:	5	Number of Primary Feeders:	30
Number of Secondary Grids:	10	Number of Grid Vaults:	50
Number of Spot Vaults:	114	Number of Grid Transformers:	113
Number of Spot Transformers:	309		

While typical Secondary Grids are composed of two to four vaults with 6-8 transformers (500 kVA or 750kVA), SMUD's largest Secondary Grid employs 21 vaults with 48 transformers. SMUD's Spot vaults range in size between 2-500 kVA to 5-1000kVA transformers each.

4. Loading

The Network system is comprised predominately of high-density commercial and retail type customers who account for well over 90% of the total Network load. This is reflected in the daily load profiles of the Network, with peak usage occurring between the hours of 10 AM and 4 PM with a very sharp load drop off after 5 PM. Load steadily increases at around 7 AM until it reaches an apex at around 2 PM. Load then dramatically drops off around 5 PM, typical of business hours. The loading differences between weekends and weekdays are fairly dramatic, upwards of 50% in peak loading differences. Again, this is consistent with the type of load seen throughout the Network.

5. Los Angeles Department of Water and Power

The Los Angeles Department of Water and Power has no Grid or Spot Network systems.

6. Other California Utilities

There are no other Spot or Grid Network systems in California.

7. Summary of California's Secondary Networks

	MVA Total	MVA Spot	MVA Grid	Network Systems	Feeders	Vaults	Xformers	Customers
PG&E - San Francisco	420	214	206	10	57	650	1,100	17,420
PG&E - Oakland	82	42	40	2	12	110	212	1,400
SCE – Long Beach	44	20	24	1	7	52	130	1,100
SMUD - Sacramento	81	51	30	5	30	164	422	2,549
Totals	**627**	**327**	**300**	**18**	**106**	**976**	**1,804**	**22,469**

Statewide Demand in 2005	57,500	Statewide Demand Served by Networks = **1.1%**	Statewide Customers Served by Networks = **.17%**	13,500,000

Network Systems – Systems or groupings of primary feeders serving Network loads

B. Distributed Resources Interconnected to Secondary Network Distribution Systems in California

Building	City	Utility	Network Type	Date Operational	Size [kW]	Generator Type	Prime Mover
Moscone Convention Center	San Francisco	PG&E	4 kV Spot Network	Mar-04	675	Inverter	PV
Elihu M. Harris Building	Oakland	PG&E	277/480 Spot Network	2002	600	Synchronous	IC Engine
199 Fremont St	San Francisco	PG&E	277/480 Spot Network	Nov-03	800	Synchronous	IC Engine
595 Market St	San Francisco	PG&E	277/480 Spot Network	Apr-04	1030	Synchronous	IC Engine
Bechtel Headquarters	San Francisco	PG&E	277/480 Spot Network	Nov-03	1200	Synchronous	IC Engine
One Market Plaza	San Francisco	PG&E	277/480 Spot Network	1Q 2003	1500	Synchronous	IC Engine
EBMUD	<<Oakland>>	PG&E	277/480 Spot Network	May-03	600	Inverter	Micro Turbines
201 Mission	<<San Francisco>>	PG&E	277/480 Spot Network	Jun-05	750	Synchronous	IC Engine
Ritz-Carlton	<<San Francisco>>	PG&E	277/480 Spot Network	Dec-05	240	Synchronous	Micro Turbines

V. Other Network Interconnection Activities

A. Other Projects and Sources of Information

There are a number of state and regional activities that are in the process of discussing and developing experience, data, and requirements related to Secondary Network Interconnection. The Rule 21 Working Group has been coordinating with all of the following activities, with in most cases two or three individuals from Rule 21 participating.

1. Distributed Utility Integration Test (DUIT)

The DUIT project, run by Distributed Utility Associates is investigating the interaction of GF and the utility distribution system. An upcoming activity will be to review GF on Networks. To that end, DUIT has developed the report, a *Network Distribution Systems Background And Issues Related To The Interconnection Of Distributed Resources* (www.nrel.gov/docs/fy05osti/38079.pdf), to provide a basic discussion of Secondary Network design theory and begin enumerating the possible issues that need to be considered when connecting GF to Secondary Networks. More information on the DUIT project can be found at www.dua1.com/DUIT.

2. Massachusetts DG Collaborative (MDGC)

The general MDGC site is
www.masstech.org/renewableenergy/public_policy/DG/collab_overview.htm

It has some great resources in a number of areas beyond network interconnection--take a look, for example at the list of documents related to DG value on the Distribution Planning Workgroup page. Network-specific info is at:
www.masstech.org/renewableenergy/public_policy/DG/resources/network.htm

The 2005 annual report, which summarizes their 2005 activities, including networks (in Chapter 2), is at:
www.masstech.org/renewableenergy/public_policy/DG/2005_annualreport.htm.

MDGC has been hosting monthly coordination conference calls involving state energy agency personnel (primarily) and others from Massachusetts, California, New York, New Jersey

The following table lists some known GF installed on Secondary Networks in other states (from Massachusetts DG Collaborative)

Building	City	State	Utility	Network Type	Date Operational	Size [kW]	Generator Type	Prime Mover
Dormitory Authority Headquarters	Albany	NY	NiMo	Secondary Spot Network	Dec-01, Feb-04	15	Inverter	PEM Fuel cell
Conde Nast Building	New York City	NY	ConEd	Secondary Spot	Feb-00	20	Inverter	PV
Coast Guard Building (Williams Bldg)	Boston	MA	NSTAR	Secondary Spot Network	Phase 1 Oct. '99	30	Inverter	PV
Conde Nast Building	New York City	NY	ConEd	Secondary Spot	Feb-00	400	Inverter	Fuel Cell
Coast Guard Building (Williams Bldg)	Boston	MA	NSTAR	Secondary Spot Network	Phase 2 Aug. '02	70	Induction	IC engine
Museum of Science and Industry	Chicago	IL	ComEd	12.5 kV Spot Network	Jan-03	1750	Synchronous	IC Engine
Peak Shaving/Load Control	Detroit	MI	DTE	4 kV Spot Network	operational	> 1000	Synchronous	IC Engine
Data Processing Centers	Dallas/Fort Worth	TX	Oncor	Secondary Spot Network	operational	> 5000	Synchronous	IC Engine

3. IEEE standards

IEEE Std 1547-2003 *Standard for Interconnecting Distributed Resources with Electric Power Systems*, includes brief language regarding minimum requirements for interconnecting GF to Spot Networks. Grid Networks were left for future development.

A new project, IEEE P1547.6, *Draft Recommended Practice For Interconnecting Distributed Resources With Electric Power Systems Distribution Secondary Networks*, has been started to further develop requirements for Secondary Network Interconnection. Summary information is available at http://grouper.ieee.org/groups/scc21/1547.6/1547.6_index.html

4. EPRI White Paper

An EPRI White Paper entitled "Interconnection of Distributed Energy Resources in Secondary Distribution Network Systems" has been published and is available at www.epri.com under report number 1012922 (www.epriweb.com/public/000000000001012922.pdf).

B. Existing Network Interconnection Requirements

For any new Generating Facilities to be interconnected to the PG&E's Secondary Spot Network System, PG&E requires customers to follow the requirements as described in *Secondary Spot Network System Requirements For Distributed Generation Interconnection* (PG&E's Bulletin 2004 PGM-10, www.pge.com/docs/pdfs/biz/transmission_services/contracts_tariffs/di_handbook/Secondary_Spot_Network_Req.pdf). These requirements are intended to provide safe and reliable operation for both PG&E and customers. PG&E is developing requirements for Grid Networks (see Section VIII.A.2).

Several state and regional organizations and utilities have developed requirements for Network Interconnection, including those listed in the following:

Document	Location
New York Standardized Interconnection Requirements	www.dps.state.ny.us/distgen.htm
Con Ed's interconnection web page has some network-specific information:	http://m020-w5.coned.com/dg/default.asp
Texas interconnection manual and interconnection rules 25.211 and 25.212 In particular, see paragraph h in 25.211	www.puc.state.tx.us/electric/projects/21965/21965.cfm
New Jersey's Net Metering and Interconnection Standards for Class I Renewable Energy Systems as defined in N.J.A.C.. 14:4-9	www.bpu.state.nj.us/wwwroot/secretary/NetMeteringInterconnectionRules.pdf
Mid Atlantic Distributed Resources Initiative (MADRI) and PJM's model	www.pjm.com/committees/working-groups/sgiwg/downloads/20050524-item-3-madri-interconnect-proc.pdf.

A valuable resource for interconnection information across the US, though not necessarily Network-related, is the Database for State Incentives for Renewable Energy (www.dsireusa.org/). While it does primarily address incentive programs for renewables, it also lists and provides links to interconnection requirements, state by state.

VI. Issues Related to Network Interconnection

The following Table presents possible issues related to interconnecting DG in Secondary Networks. The list was derived from several sources, primarily the DUIT Network Report (Annex B), MDGC publications and draft sections of IEEE P1547.6. A separate document containing all of the source materials is available on the Rule 21 web site (www.rule21.ca.gov/technical_issues/network)

	Issue	Spot	Grid	Primary Fed	Technology Dependent	Area	Comments	Potential Solutions
1	How does the GF provide Network Transformer protection function normally provided by the feeder's protective relay?			X		Protection/ Coordination	GF connected to the Primary would be handled like any radial connected GF. Unclear what else this might address	
2	What kind of communication is necessary between the protectors and the GF?	X	X			GF Impact on Network equipment/operation		Possibly NP status via monitoring system
3	How might the GF cause false tripping of the protectors?	X	X			GF Impact on Network equipment/operation	Exporting across the NP; VAR swings?	Minimum import (Spot), limit GF capacity(Grid)
4	How might the GF prevent proper Opening protectors?	X	X			GF Impact on Network equipment/operation	Not sure how to cause this	
5	How might the GF prevent proper closing protectors?	X	X			GF Impact on Network equipment/operation	Need to understand load levels necessary for proper closing	Reduce network Xformer size, minimum import (spot), GF capacity (grid)
6	Will any Network equipment be overstressed (Fault) due to the GF interconnection?	X	X		X	GF Impact on Network equipment/operation		Testing Issue Limit GF or replace overstressed equipment

	Issue	Spot	Grid	Primary Fed	Technology Dependent	Area	Comments	Potential Solutions
7	Will any Network equipment be over loaded (normal current) due to the GF interconnection?	X	X		X	GF Impact on Network equipment/operation	Not necessaraliy a "network" issue	Limit GF or replace over loaded equipment
8	What effects will the GF have on the Network Protector relays, and what are the new relay setting criteria? What are impacts of increased time delay for low level rev power setting	X	X		X	GF Impact on Network equipment/operation	Test to determine potential impacts of delay	See Feero report for possible relay settings.
9	How will the presence of the GF affect the protectors' response to faults outside of their protection zones? (e.g. response to adjacent feeder fault, AFF)	X	X			GF Impact on Network equipment/operation		Consider low level rev power time delays (similar to requirement for regn braking of elevators)
10	Is the operation of a single-phase overcurrent device (protector fuse) a concern with the presence of GF?	X	X			GF Impact on Network equipment/operation	Does not appear to be an issue.	
11	What conditions must be satisfied before paralleling is allowed? What will be the paralleling procedure?	X	X		X	GF Paralleling requirements	Minimum import (across NP), Sufficient NP's closed, Sync tolerances met. Paralleling vs synchronization. Are different Sync tolerances required?	

	Issue	Spot	Grid	Primary Fed	Technology Dependent	Area	Comments	Potential Solutions
12	Will a dedicated transformer for the GF be required?	X	X	X	X	GF Requirements	Does not appear to be an issue (not a network-specific issue)	
13	How do requirements vary with the number of Network Transformers (eg. Dozens to hundreds spread out over a wide area?	X	X			Network configuration	Does not appear to be an issue	More xformers could ease the requirements
14	Will addition of GF impact arc detection (ozone, heat/smoke/flash)? Will requirements be different for 208 volt and 480 volt Networks because of the different arcing characteristics? How are the arcing characteristics different?	X	X			Network Configuration	Testing needed to define issue.	
15	Will the presence of, or lack of, Cable Limiters on the secondary cables result in different GF interconnection requirements?		X			Network Configuration	Not aware of any different needs	
16	(combined with 13)							
17	Will changes in power flow over the daily or weekly load cycle result in protector Cycling at a point remote from the GF's PCC?		X		X	Network Configuration		

	Issue	Spot	Grid	Primary Fed	Technology Dependent	Area	Comments	Potential Solutions
18	Will different protection requirements apply to Network systems supplied from three-wire and four-wire primaries? With delta-wye or wye-wye transformers?	X	X			Network line configuration		
19	How will the protector be prevented from isolating distributed resources from the utility system? f the GF islands, will the Network Protector relay tolerate 180 deg out of phase voltage? If the GF islands, how will the Network master (/phasing?) relay be prevented from reclosing the protector switch during an out-of-synchronism condition?	X	X	X	X	Protector breakers are not designed to interrupt fault current from generators or withstand out-of-phase conditions across the open switch.	Another islanding problem 1) Test NP to see if it can withstand 180	Replace NP Anti islanding >50% NP closed requirement Limit GF capacity Minimum import
20	What would be an acceptable ratio of the minimum customer load current over the maximum GF output to eliminate any possibility of reverse power through a protector?	X	X			Reverse power through Network Protector	This is the FIRST thing to test!!! (see 3)	
21	What action needs to be taken with a sudden loss of large load?	X	X			Reverse power through Network Protector	Issue not understood Transient low load issue?, inadvertent export? Is this really a subset of 3?	

	Issue	Spot	Grid	Primary Fed	Technology Dependent	Area	Comments	Potential Solutions
22	Can power swings or loss-of-synchronism, loss of field by rotating generators cause reverse power through a Network Protector?	X	X		X	Reverse Power through Network Protector	A testing issue	
23	Can insertion of customer PF caps cause reverse power through a Network Protector?	X	X		X	Reverse Power through Network Protector	Testing issue	
24	(Combined with 19)	X	X					
25	(Combined with 19)	X	X					
26	How can addition of GF contribute to or exacerbate cycling or pumping of NP	X	X		X		Needs testing; what constitutes “exacerbate”?	
27	Is there any fault detection (Phase or ground fault) required for GF? Should GF trip before NP?	X	X		X		Why? (MDGC issue)	
28	What equipment damage can occur due to increased time delay for low reverse power	X	X				(MDGC issue) testing needed to determine impacts	
29	Modifications to Network equipment may be problematic and costly due to access limitations, equipment age, etc.	X	X					
30								

VII. Costs Associated with Network Interconnection

The costs given in this section are meant to be representative of the costs one might encounter when trying to interconnect DER into a distribution secondary spot network such as exists on PG&E's distribution system and should not be taken as the actual costs that will be incurred. In addition, the representative costs provided below are associated with interconnecting DER into a spot network only and as such, would not pertain to interconnecting DER into a grid network. Moreover, these costs are based on averaged data received from several sources including PG&E, the San Francisco Public Utilities Commission, PowerLight Corporation and DG Energy Solutions LLC. In arriving at these costs, it should be noted that the installations reviewed to date did not require replacing or changing out the existing network protectors which if required, would only increase the DER installation costs given below. However, with the above stated qualifiers and conditions in mind, representative DER interconnection costs were deduced from data received to date from several DER installations varying in size from 400 to 1200 kW on PG&E's spot network distribution system. This review yielded the two basic cost categories which follow:

1. Special Facilities Charges
2. Taxes and Cost of Ownership Charges

A. Special Facilities Charge

In these examples, DER installation costs were at applicant's expense and financed through the utility using special facilities charges specific to the number of network protectors and relays that need replacement, and included the installed cost of a programmable controller. At PG&E, it has been determined that a programmable controller is needed to monitor network protector status and trip the DER system when the number of closed network protectors falls to 50% or less of the installed network protectors.

The range in cost per installed programmable controller has been approximately $23,000-$35,000/controller, depending on location, underground vault, etc. with historical data based on one new controller required per site.

The range in cost per installed relay replacement has been approximately $7,000- $12,000/relay with historical data based on 3 to 9 relays per site.

B. Taxes and Cost of Ownership Charge

As applicable, taxes are applied to the special facilities cost. In addition, there is a monthly cost of ownership charge that, if desired, can be present-worthed to develop an equivalent one-time charge (in lieu of the monthly cost of ownership charge). Depending on the application, the total of such charges in this category could be up to 93% of the Special Facilities Charge.

C. Example Totals

Based on the above data and assumptions, two examples of costs to interconnect DER into a secondary distribution spot network are given below.

1. Lower-End Cost Example to Connect DER into a Spot Network – Assume that no network protectors have to be replaced and that the installed cost of a programmable controller is $30,000 and that 3 relay replacements are required at $10,000 each. The Special Facilities Charge would then be $60,000. Assuming a 90% factor of the Special Facilities Charge to account for the Taxes and Cost of Ownership Charges, $54,000 would be added to $60,000 for a total one time interconnection cost of $114,000.

2. Higher-End Cost Example to Connect DER into a Spot Network - Again assume no network protectors have to be replaced and that the installed cost of a programmable controller is $30,000 and that 7 relay replacements are required at $10,000 each. The Special Facilities Charge would be $100,000. Assuming a 90% factor of the Special Facilities Charge to account for the Taxes and Cost of Ownership Charges, $90,000 would be added to $100,000 for a total one time interconnection cost of $190,000.

Using the above methodology and extrapolating from these examples, it is estimated that the total cost to interconnect DER into a typical spot network distribution system would range from $100,000 - $200,000 per site based on the assumptions listed above. If only the Special Facilities Charges are considered, then the cost would range from approximately $50,000 to $100,000 per site. Finally, it should be noted that future costs to interconnect DER into spot network distribution systems could vary depending on unique field conditions encountered and new requirements that may be imposed.

VIII. Working Group Recommendations

Developing the preceding status review has given the Rule 21 workgroup members a better perspective on the situation in California, contact with a wide range of interested parties, and exposure to the debate in other venues. Through this review, a number of as yet unresolved issues have been identified (Section VI). While it is possible that many of these will be found to be of little or no consequence, some will undoubtedly result in specific requirements for and limitations to Network Interconnection. The recommendations below show that there is still significant work to do to arrive at consensus requirements. Rule 21 workgroup should remain formally involved in the various ongoing activities that are attempting to resolve these issues, including IEEE P1547.6, the MDGC and other state collaborative groups, and DUIT.

A. Suggested Changes to Rule 21

1. Proposed Initial Review Process Screen for Spot Networks

Currently, there are no suggested IRP criteria for Spot Networks. The Grid Network screen below would serve an acceptable albeit conservative starting point.

2. Proposed Initial Review Process Screen for Grid Networks

The following set of draft criteria is proposed for consideration as a Rule 21 IRP screen for Grid Networks. The draft criteria area based on a document developed by PG&E. It is suggested that these criteria be used on a trial basis to provide feedback on the suitability of the criteria. .

Background:
Currently, neither the IEEE 1547 standard nor the CPUC Rule 21 has any guideline or criteria for interconnection of any type of generation units to the Secondary Grid (Area) Network System. IEEE has recently announced formation of a new technical subcommittee (IEEE 1547.6) to address the interconnection issues. Also, the Department Of Energy (DOE) and the California Energy Commission have jointly funded a research project called Distributed Utility Interconnection Testing - Phase 2 (DUIT – phase II) to determine the concerns and perform relevant tests in the interest of setting guidelines in this area.

Interim Criteria:
On an interim basis, PG&E has developed criteria for interconnection of a small level of inverter based customer generation to its Secondary Grid Network System. Because the maximum level of generation that could be interconnected to the Secondary Grid Network System is unknown at this time, this "Trailblazer" effort should be viewed as a trial basis only, and PG&E reserves the right to suspend it at any time. PG&E has initiated the Trailblazer effort in a proactive attempt aligned with the State of California's Energy Action Plan.

Error tolerance levels are typically within 5%. Therefore, PG&E determined for this Trailblazer effort only, the aggregate generation a levels below 2% of the verifiable minimum load would be an acceptable starting point at Grid Network. This is less than half of the typical tolerance level and therefore should not compromise the safety, reliability and operation of the Secondary Grid Network System for our customers.

PG&E expects to replace the Trailblazer criteria when either the IEEE 1547 or CPUC Rule 21 standards are updated to include guidelines for interconnection to the Secondary Grid Network System.

The Trailblazer criteria require that the generation meets all of the following conditions simultaneously:
1 –Proposed GF must be 11 kVA or less.
2 – Units must be "Certified" Inverter-based as prescribed by CPUC Rule 21.
3 – GF's over 1kW must be less than or equal to 50% of the interconnecting customer's estimated minimum load during the operation of the inverter.
4 – The aggregate of all interconnected units to an individual grid must be below 2% of that Grid's estimated minimum load.

Notes:

a) Condition 4 above sets an upper bound on the total capacity of generation that maybe received for a particular secondary grid. Once, this capacity has been exhausted, further interconnection applications to that grid will be denied until appropriate guidelines are added to IEEE 1547 or CPUC Rule 21.

b) The PV units meeting the above criteria will be interconnected without any additional requirement or metering.
c) PG&E will reserve the right to suspend, change, modify, or add to the above conditions based on the results from future test reports or guidelines as they become available.
d) For PV, the minimum load refers to the Day Time minimum.

B. Suggested Changes to Supplemental Review Guideline

The working group will add an action item to consider PG&E Spot network requirements[6] as the basis for changes to the Supplemental Review Guideline.

C. Topics and Issues Needing Additional Information or Testing

The table of issues in Section 6 provides some guidance as to what the Working Group believes are issues needing further information. In particular, the following have been suggested as topics that could be tested to provide

- Minimum load necessary to allow NP's to reclose
- Minimum load necessary to prevent NP's from opening

6 www.pge.com/docs/pdfs/biz/transmission_services/contracts_tariffs/di_handbook/Secondary_Spot_Network_Req.pdf

Annexes

Annex A: Work Plan, Rule 21 Working Group Interconnection Rules for Secondary Network Systems

1 Introduction

The requirements for interconnecting generating facilities to secondary network systems are different than those for interconnections to radial systems. In the secondary network system, there are technical requirements to be considered particularly with the design and operational aspects of network protectors that are not required on radial system. In California, the major secondary network systems are located mainly in the metropolitan areas of San Francisco, Oakland, and Sacramento. Several generating facility projects have been interconnected to various secondary network systems over the past few years. Due to lack of technical information and clear guidelines, there have been issues with some of these interconnections. By the current screening process in Rule 21, applications for interconnection to secondary networked systems are advanced to the "supplemental review" stage. Due to the complexities and varieties of protective schemes used in the networked systems, most of these interconnections require a detailed study. Without suitable guidelines, utility companies will have to study each project and establish requirements on a case by case basis to allow a safe and reliable interconnection of these generating facilities to their secondary network system.

There has been an interest from the California Energy Commission's Integrated Energy Policy Report committee and other stakeholders to determine if any simple and uniform rules for interconnection of DG to networked systems maybe added to Rule 21 (or to the Supplemental Review Guideline). Similar interconnection issues and the need for guidelines have also been identified in other part of United State. Some of the on-going efforts by other utilities and engineering groups addressing and working on this issue are as follows:

- ✓ Massachusetts Technical Collaborative Working group is developing network requirements for that state's DG interconnection rules.
- ✓ California Energy Commission in collaboration with DOE has initated the development of a testing program to study network interconnnections. Testing will conducted by the Distributed Utility Associates in California as Phase 2 of the Distributed Utility Integration Test (DUIT) project.
- ✓ PG&E Draft requirements
- ✓ Expand the status of these items

2 Work Plan Outline

Rule 21 technical working group has developed the following plan outline for this purpose.

2.1 Basic Objectives:

- Define the issues
- Determine general requirements (i.e., Rule 21 Section D)
- Determine requirements for simplified interconnection (i.e., Rule 21 Section I)
- Develop Supplemental Review pathways.

2.2 Tasks:

1. Develop definitions, characteristics, and design philosophies for different types of networks to provide a common basis of understanding
   - DUIT report
   - MDGC Report
2. Identify network systems in CA
   - Location
   - Physical characteristics
3. Identify the stakeholders nationwide who may be able to provide information
   - Utilities with network systems
   - DG suppliers
   - Customers on network systems who may be interested in DG
   - Regulators
   - Network equipment providers and other experts
4. Identify and Investigate other Projects and sources of documentation
   - DUIT Network meeting and Network-related testing
   - Massachusetts DG Collaborative
   - PG&E white paper
   - IEEE 1547.6 (PAR to be submitted)
   - Manufacturer data sheets/white papers
   - FOCUS Field monitoring study
   - EPRI Study (?)
5. Identify and investigate the availability of other Rules and requirements
6. Identify and investigate existing GF on networks
7. Identify problems and solutions
   - Experience from utilities
   - Experience from system integrators
8. Investigate costs
   - Protection Schemes
   - Protector rework

Annex B: DUIT Report on Networks

The Distributed Utility Integration Test project (DUIT, www.dua1.com/DUIT), has developed a base document describing Secondary Networks and enumerating some of the issues related to GF interconnection. The published version of the report is available at www.nrel.gov/docs/fy05osti/38079.pdf.